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SHORT COMMUNICATION

Determining the age of young silver birch (*Betula pendula*) trees growing on former agricultural

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Abstract. In Poland, according to the law (amendment of the act of 21st May 2010) – on the provision of information on the environment and its protection, public participation in environmental protection and environmental impact assessments etc. (Official Law Journal article 08.199.1227, as amended) – the owner can cut down trees without permission, if they do not exceed the age of 10 years old. However, if an owner happens to cuts down a tree on his property without knowing the age of the tree, he is liable to prosecution under this act.
The aim of this study is to verify whether there is a possibility to calculate the actual age of silver birch trees growing on farmer agricultural lands using features that enable age of standing trees to be identified. Using these criteria, owners would be able to calculate the age of trees on their own.
The research used 183 sample trees located on three research plots. For each tree, the dbh, height and prepared samples of wood from the trees base were used to give the age of the tree. The relationship between age and dbh, as well as between the age and the height was examined. The strength of correlation was compared and the strongest was used in the proposed model. Using these correlations two types of charts were constructed to estimate the age of young birches on the basis of dbh and height.

Key words: silver birch, age, dbh, height, former agricultural land

1. Introduction

The provisions of the Nature Conservation Act of 16th April 2004 (the 2004 Act) and its amendment dated 21st May 2010 (the 2010 Act) state that the owner of land cannot cut a tree without permission, unless it is a fruit tree, if its age exceeds 10 years. Should the owner assume that the tree which he is going to cut is younger, and after cutting it, it turns out differently, he risks paying very heavy penalties. The payment of penalties is governed by the relevant provisions (Decree of the Minister of Environment of 13th October 2011). It is worth noting that charges are applicable not only for cutting trees without permission, but also for obtaining a permit to cut trees. Removing trees in the area designated for commercial activity requires payment of fees; no fees are required from persons who do not carry out commercial activity (e.g. the removal of trees for the construction of their own houses). The amount of a fee for tree removal depends on the circumference of the trunk measured at a height of 1.30 m from the ground, as well as on tree genus and species. In 2012, fees could not exceed the amount of PLN 319.40 per 1 cm of diameter at breast height for trees with a circumference of 25 cm. In the case of larger circumferences, fees increase with every centimetre, for example, for a circumference of 51–100 cm, the maximum charge is PLN 757.13; for a circumference of 201–300 cm as much as PLN 1774.52. In extreme cases, like trees with a circumference of over 700 cm, the fee may reach even PLN 4140.55 for every

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centimetre of the circumference. Penalties for illegal tree felling are three times the above fees charged for the permit.

Determining the age of standing trees is very difficult for most of the species. For some coniferous species, tree age can be determined by whorls, but this is possible at an early age. Other methods require interference in the tree tissue. Using a specialised device called Pressler's borer, one can take a core sample to count the annual growth rings. Assuming that the sample is taken at the closest possible height from the ground (the size of the sample usually equals half the length of the handle), and that there is no difficulty in determining the annual growth ring boundaries, the method gives accurate results, provided that the number of growth rings in the core is increased by adding the number of years that the tree has needed to reach the height at which the sample is taken. Growth rings are best seen in the cross section of cut trees. For these reasons, the owner of land who lacks expertise knowledge and equipment can hardly determine the age of the trees growing on his property.

In recent years, the proportion of former agricultural land in Poland has increased. It is characterised by the occurrence of secondary succession in which a great role is played by silver birch (*Betula pendula* Roth) due to its low habitat requirements and expansiveness (Jaworski 1995; Szymański 2000). Birch, as a pioneer species, very quickly grows on new sites (Karney et Pawłowicz 1952; Tomanek 2008), and so it can be found on a large part of the land excluded from further agricultural production. Due to the ecological properties of birch, where until recently there was cultivated field, after a few dozen years or longer a forest develops. This can pose a problem for the owners of land who might eventually want to cultivate it again or designate it for investments or other forms of use.

An attempt to remove trees from such areas without the consent of the appropriate authorities may turn out to be breaking of the law on the grounds that the trees have exceeded the age limit of 10 years. Regrettably, the landowner is not able to determine the age of standing trees because of the previously described general difficulties. In the case of birch, it is even more difficult to estimate the age of this tree species even on a cross section due to its specific diffuse-porous wood. Only using a microscope can one specify the number of annual growth rings rather correctly.

For these reasons, an attempt is made in this paper to indicate alternative methods of estimating the age of birch that would require neither cutting down a tree nor expertise knowledge or equipment. The purpose of this paper is to identify tree properties strongly associated with age, with the intention of using these dependencies for age estimation. Two tree characteristics are selected as relatively easy to measure, especially in young trees: breast height diameter and height. First, the possibility of specifying the age by using these features is to be checked. The degree of correlation with age would allow choosing a characteristic better suited for building tables to estimate the age of young birches. Such tables might prove useful for the owners of land on which silver birch has grown. The tables would be a simple way of estimating the age of trees and might become the basis for making a responsible decision about cutting without permission or applying to the respective Authority for the relevant permit.

2. Research material and methodology

The research material includes discs cut out from the trees whose age has not exceeded 10 years (confirmed by interviews) grown on three research plots. The first two plots are located in the village of Chudolipie (Mszczonów Commune, Żabia Wola County, Mazowsze Province), while the third plot is in the locality of Ujście (Janów Lubelski Commune, Janowski County, Lubelskie Province).

The trees grew on arable land classified into classes V, VI and VIz, that is, on poor soils, little useful for agricultural production (Woch 2007; Zawadzki 2009). Samples on plot I (open terrain, soil class VIz) were collected from the trees cut under power lines in the central part of the lot. In plot II (surrounded by a pine stand, soil class VI), a transect was established along the entire area. Sample trees were cut at a distance of about 0.5 m from the axis of the transect. Sample trees from plot III (open terrain, soil class V) were taken in the same way. A transect of about 1 m in width was established on the entire plot on which trees were cut one by one until the total number of cut trees reached 61.

The measurements were carried out in December 2009 and January 2010. The diameter and height of each sample tree at a height of 1.3 m from the ground were measured. Also a disc was cut out at the base of the tree (from the height less than 5–10 cm from ground level), which in the case of pioneer species shows the first year growth ring on the cross section. This is of great importance in the further processing of the materials and precise determination of the age of each of the trees. A total of 183 discs were taken from all plots (61 discs

each from plots I, II and III). The discs were transported to the laboratory where they were sanded to remove dirt. Then they were watered to better expose the boundaries of annual rings. Tree ring boundaries were examined under the microscope with ×15 magnification in the Tree Ring Lab of the Department of Dendrometry and Forest Productivity in Warsaw University of Life Sciences – SGGW, and the tree rings were counted, so that it was possible to determine the age of each disc. Due to the fact that these fragments were extracted from the bottom of the trunk (near the base), the number of rings on the discs indicates the age of the tree. Each tree ring corresponds to one growth season during which the tree grew (Hejnowicz 2002; Zielski et Krapiec 2004). An analysis of regression and correlation of thickness and height with tree age was carried out.

3. Results

The relationship between age and diameter at breast height was studied for three different classes of soil quality (Fig. 1). The regression line for this relationship is sloped in relation to the axis of abscissae at a certain angle, which may indicate a statistically significant relationship between age and dbh. This is confirmed by Pearson's (linear) correlation coefficient which for plot I (class VIz) is 0.369, for plot II (class VI) 0.495 and for plot III (class V) 0.639, and by the correlation coefficient significance test, which for all the plots is p=0.000. The variation in the age of trees can be explained by the relationship between this characteristics and dbh which is 13.59% for plot I, 24.52% for plot II and 40.87% for plot III.

For each plot, an equation has been developed to determine the age based on dbh (d 1.3), expressed in cm:

Plot I: $age = 4.52074 + 0.3894 \cdot d_{1.3}$
Plot II: $age = 4.16963 + 0.767109 \cdot d_{1.3}$
Plot III: $age = 4.88045 + 0.661744 \cdot d_{1.3}$

Also the relationship between the age and the height of the tree was examined. The scatter of these

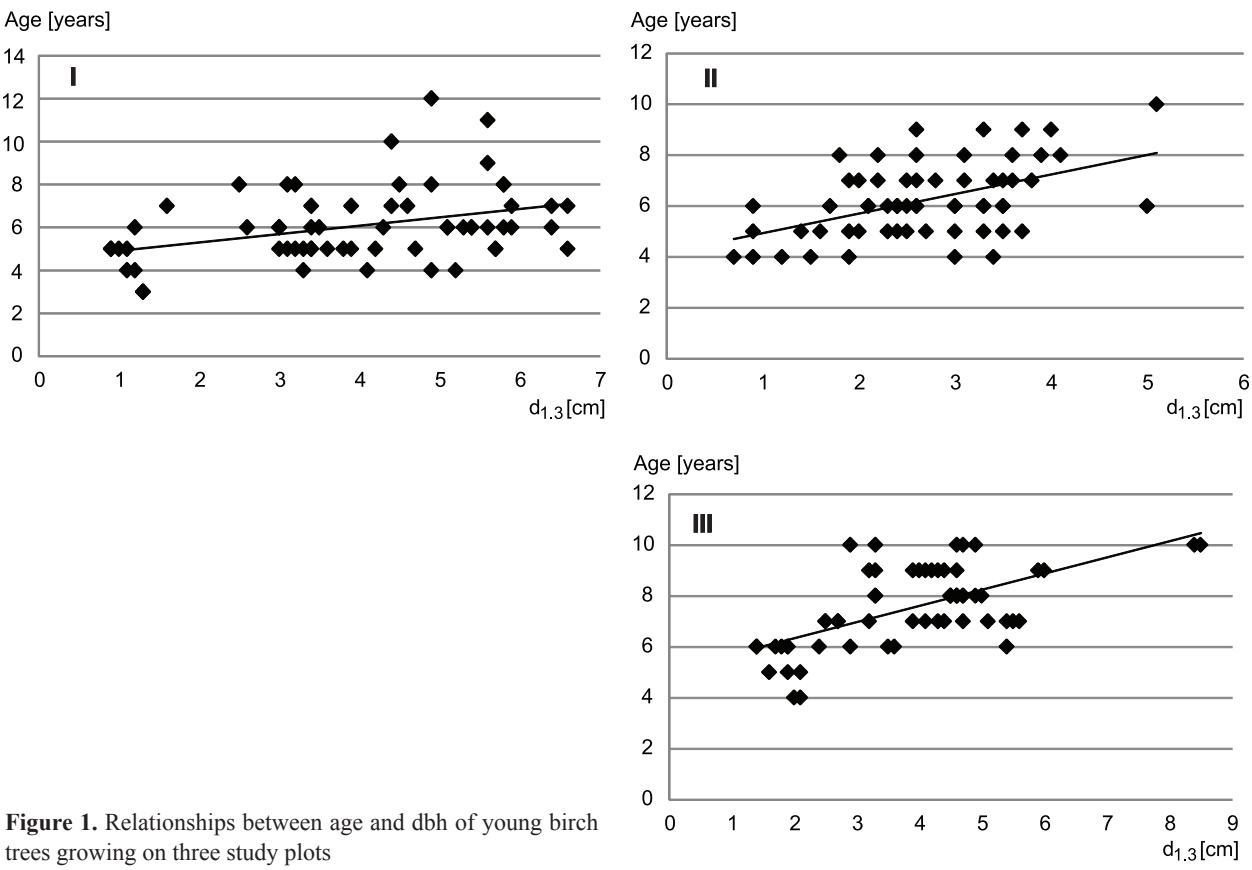

Figure 1. Relationships between age and dbh of young birch trees growing on three study plots

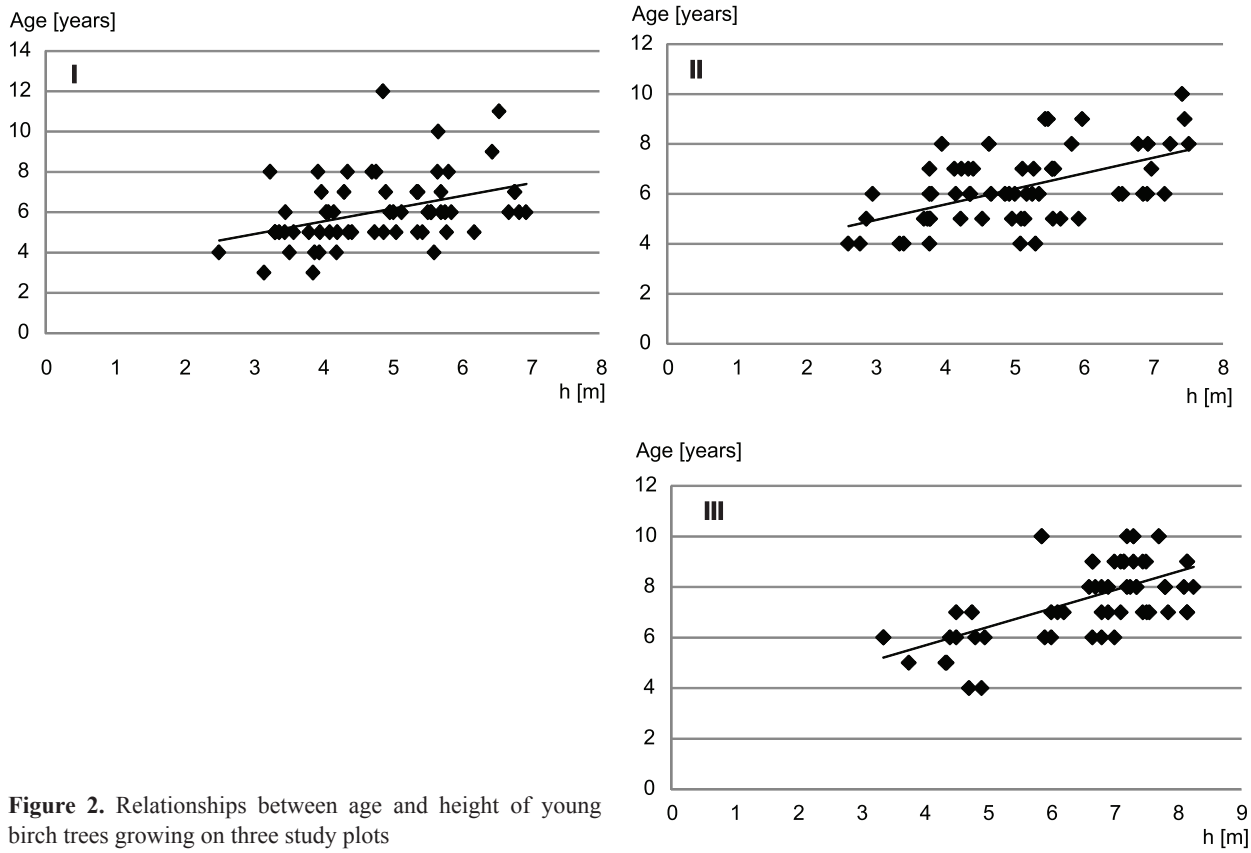

Figure 2. Relationships between age and height of young birch trees growing on three study plots

Table 1. Tables for determining the birch age based on dbh

d [cm]	Quality classes of agricultural land*								
	VIz			VI			V		
	Age [years]								
	mean	min	max	mean	min	max	mean	min	max
1	5	4	5	5	5	5	6	5	6
2	5	5	6	6	5	6	6	6	7
3	6	5	6	6	6	7	7	7	7
4	6	6	6	7	7	8	8	7	8
5	6	6	7	8	8	8	8	8	8
6	7	7	7	9	8	9	9	9	9
7	7	7	8	10	9	10	10	9	10
8	8	7	8	10	9	11	10	10	11
9	8	7	9	11	10	12	11	10	12
10	8	8	9	12	11	13	11	11	12
11	9	8	10	13	11	14	12	11	13
12	9	8	10	13	12	15	13	12	14

* Quality classes of agricultural land describe the quality of land in terms of value to agricultural production; class I corresponds to the highest agricultural value and class VI to the lowest; z – land designated for afforestation.

Table 2. Tables for determining the birch age based on height

h [m]	Quality classes of agricultural land*								
	VIz			VI			V		
	Age [years]								
	mean	min	max	mean	min	max	mean	min	max
1	4	3	4	4	3	4	3	2	4
2	4	4	5	4	4	5	4	3	5
3	5	5	5	5	5	5	5	4	5
4	6	5	6	6	5	6	6	5	6
5	6	6	6	6	6	6	6	6	7
6	7	6	7	7	7	7	7	7	7
7	7	7	8	7	7	8	8	8	8
8	8	7	9	8	8	8	9	8	9
9	9	8	10	9	8	9	9	9	10
10	9	8	10	9	9	10	10	9	11
11	10	9	11	10	9	11	11	10	12
12	11	9	12	11	10	11	12	11	12

* As in the Table 1.

characteristics is shown in Fig. 2. The slope of the regression line is steeper in relation to the vertical axis than in the case of the relationship between age and dbh. The value of the correlation coefficient for the examined sample is as follows: for plot I 0.395, for plot II 0.545 and for plot III 0.620; the correlation coefficient significance test also indicates a statistically significant relationship between the height and the age of the tree in all populations from which the samples were taken (p=0.000). The variation of age of the birches in the examined stands can be explained on the basis of height which is 15.63% for plot I, 29.71% for plot II and 38.43% for plot III, as evidenced in the value of the coefficient of determination. The relationship between age and height is, therefore, much stronger than the relationship between age and dbh. The empirical equation enabling predicting the age of a tree on the basis of its height expressed in metres is given below:

Plot I: $age = 3.02036 + 0.629241 \cdot h$
Plot II: $age = 3.07925 + 0.624321 \cdot h$
Plot III: $age = 2.56588 + 0.749741 \cdot h$

Table 1 is designed to determine the age of young birches on the basis of dbh in centimetres, and Table 2 to determine the age of young birches on the basis of height. Middle values are calculated on the basis of the regression equation obtained in the course of an earlier analysis, while the lower and upper values are estimated using confidence intervals.

4. Discussion

In accordance with the amended Nature Conservation Act (Act of 21st May 2010), the age limit for cutting a tree without permission is 10 years. This provision is precise and clear; however, its application is associated with the need to determine the age of the tree to be cut, which in many cases is impossible without interfering in tree tissue, and this in turn requires the use of specialised equipment (Pressler's borer), which generally the owner of the tree does not have. This leads to a situation that the tree is often cut down without first determining its age, which puts the owner at a risk of paying a penalty governed by the relevant provisions. For the owners wishing to cut trees, other solutions helping them to specify their age should be sought. In this paper, an attempt is made to solve this problem by estimating the age of young birches on the basis of the characteristics that can be measured on standing trees: breast height diameter and height.

The studies show that both the diameter at breast height and height are significantly correlated with the age of trees, and that the relationship between age and height is stronger. The coefficient of determination,

indicating what percentage of the variation in age can be described on the basis of an independent variable, is almost twice as high for height than for breast height diameter. However, in both cases, these relationships are not very strong. Therefore, it is not possible to specify the exact age of a given tree based on dbh and height.

It should, therefore, be reconsidered whether the reference to the age limit in the regulations is a good option. It is difficult to determine the age of trees with the naked eye, and each such error may result in high financial penalties. It would be much easier if the law specified the size of a tree qualifying it to be cut without the need to hire a specialist to determine its age and without interfering in tree tissue. The circumference of the trunk at a height of 130 cm from the ground could serve the purpose. Therefore, every landowner wanting to cut down a tree on his property could, without using special equipment, but only a ruler, easily determine whether such a tree can be cut without permission.

By the time the legislator will have introduced such changes, the authors of this paper propose to use Tables 1 and 2 to estimate the age of trees on the basis of the characteristics that are easier to measure, such as diameter or height. However, it should be remembered that the proposed ranges of values for these characteristics are typical, and that older trees may fall within this range.

The proposed tables may help in making a decision on what trees to cut down; however, they do not precisely define the age of the tree. The tables include typical age values for the given size of a tree; however, the minimum and maximum values may be included in a much wider range. Both trees and other living organisms are exposed to many external factors, which are responsible for a large variation of the examined characteristics. In view of the fact that the research was based on trees growing on the poorest soils (classes V, VI and VIz), they are not representative of young birches growing on more fertile soils. They may also prove unrepresentative of the trees in other environmental conditions.

While building the proposed tables it would therefore be advisable to take into account the research material from different regions of Poland representing different classes of soil fertility on post-agricultural land and different climatic conditions. It should also be noted that these tables can be useful in estimating the age of birch trees, but do not solve the whole problem. It is the provisions that should, in a simple and clear manner, define the conditions associated with cutting trees, so that every owner himself, without assistance and specialist knowledge, is able to correctly determine whether the trees to be cut meet all the necessary criteria.

5. Conclusions

The age of trees in the birch stands growing on post-agricultural land as a result of natural regeneration is very variable. Differences in age of trees on a single plot may be even 8 years.

A statistically significant relationship between the age of young birches and their breast height diameter and height was confirmed. These dependencies were used to build tables allowing estimation of the age of trees on post-agricultural land on the basis of dbh or height. In view of the fact that tree height is the feature more strongly correlated with the age of the tree, tables based on tree height may prove more accurate. These relationships are not sufficiently strong to read the age from the tables as exact and definite; however, they can be helpful in making a decision on which tree to cut.

The results obtained highlight the need to modify the provisions relating to cutting trees without a permit in such a way as to include the criteria that every landowner would be able to define without having specialised knowledge and equipment. If the regulations do not change, it will be necessary to build such tables as proposed in this paper on the basis of which it will be possible to determine the age of the tree of a given species according to the characteristics that are easy to measure. However, to build such tables, much more extensive research material, representative of different regions of Poland, will be needed. It is also necessary to search for characteristics with stronger correlations to age than tree diameter at breast height and height.

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